Automated, Quality Assured and High Volume Oriented Production of Fiber Metal Laminates (FML) for the Next Generation of Passenger Aircraft Fuselage Shells

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25. April 2019, Montreal / Canada

AIRBUS synthesites DLR Fraunhofer IFAM

Automated, Quality Assured Production of Fiber Metal Laminates
Introduction – Who we are? – CFK Nord

DLR

- ProductionTechnology Single Components
- Virtual Composite Product Development

Fraunhofer IFAM

- Assembly Technology
- Joining Technology
- Prototype Assembly

Technische Universität Carolo-Wilhelmina zu Braunschweig

TU Clausthal

Leibniz Universität Hannover

Automated, Quality Assured Production of Fiber Metal Laminates
Introduction – Fibre Metal Laminates – Actual usage in aircrafts

A **fiber metal laminate** (**FML**) is one of a class of metallic materials consisting of a laminate of several thin metal layers bonded with layers of composite material!

- Behavior of metal structure with advantages concerning
  - Weight saving
  - No fatigue SSI / ALI for FML
  - Large Damage Capability
  - …

- Large-scale deployment of FML in the Airbus A380

- 22 FML panels are imanufactured in a manually process
  - 17 FML panels manufactured by FOKKER (NL)
  - 5 FML panels manufactured by Premium Aerotech (GER)

Source:PAG

Automated, Quality Assured Production of Fiber Metal Laminates State of the Art vs Fuselage of the Future (Project AutoGlare 2015 - 2018)

- What does the actual production look like today?
  - Manual process chain for the production of FML panels
  - Actual output of the process chain
    - ~300 m^2 in a month

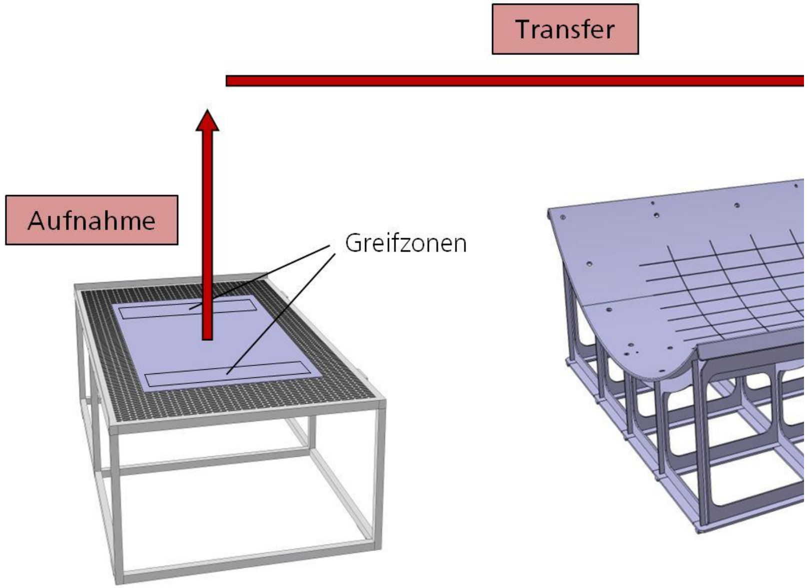
- Industrial objectives
  - Presentation of a continuous and automated manufacturing of FML components to reach a cadence of 60A/C per month - equal to 10.000m^2 per month
  - Reproducible and consistent product quality through increasing process reliability

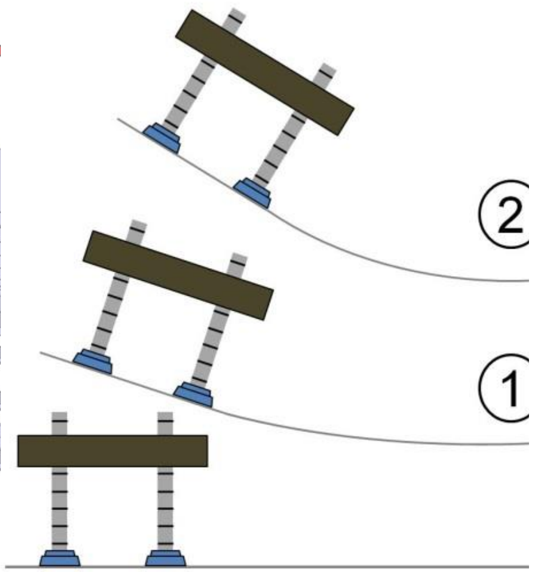
Actual process chain not suitable for high rates!

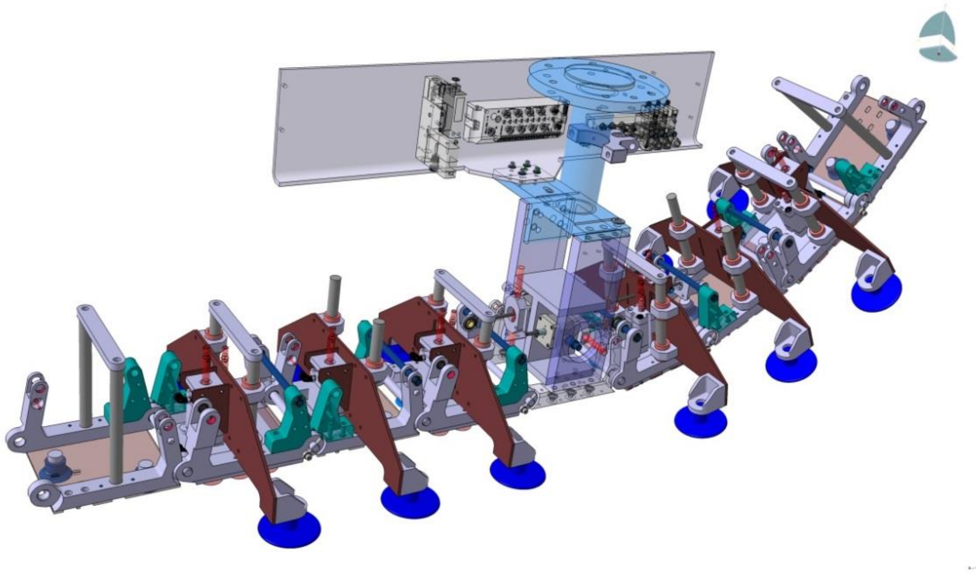
Automated, Quality Assured Production of Fiber Metal Laminates
Automated Placement of Aluminium Foils

Motivation and project goals

- Development of automated handling and storage of long aluminum foils
- Validation of the technology for plane (2D) and pre-curved blanks (3D)







Automated, Quality Assured Production of Fiber Metal Laminates
Automated Placement of Aluminium Foils

Tasks and results

For a demonstrator of 7 m x 2 m size a total of 15 aluminum sheets are automatically placed by cooperating robots

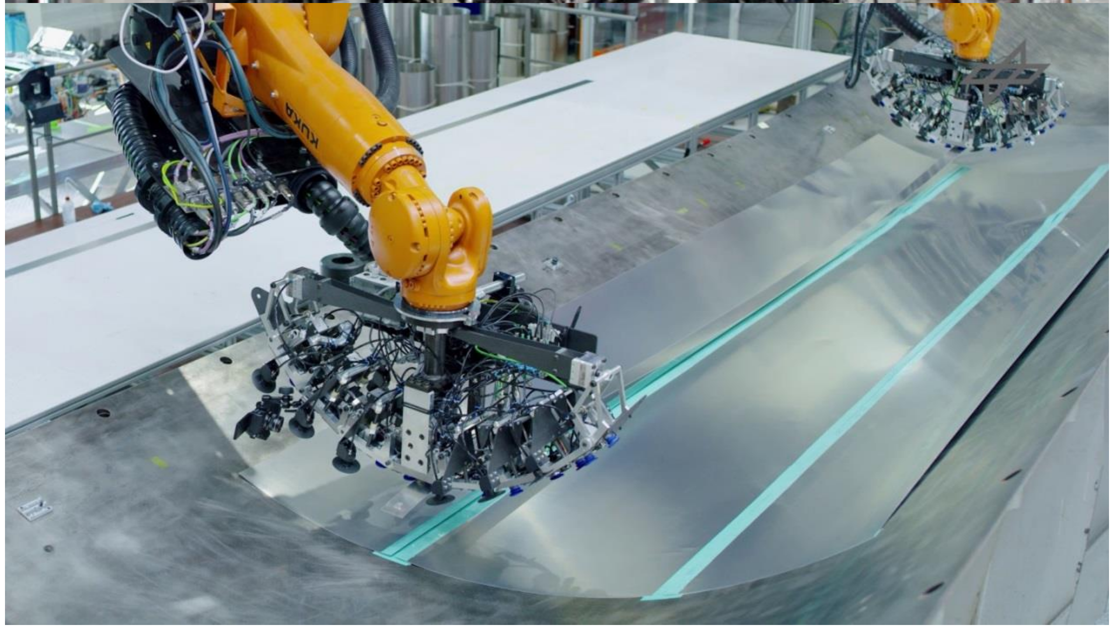
Two types of sheets can be distinguished:

- longitudinal sheets with a length of 5800 mm
- circumferential sheets with a m size of 2200 mm x 850 mm

The aluminum can be handled without damaging the sheet

Evaluation of accuracy

- An accuracy of ±2 mm can be achieved

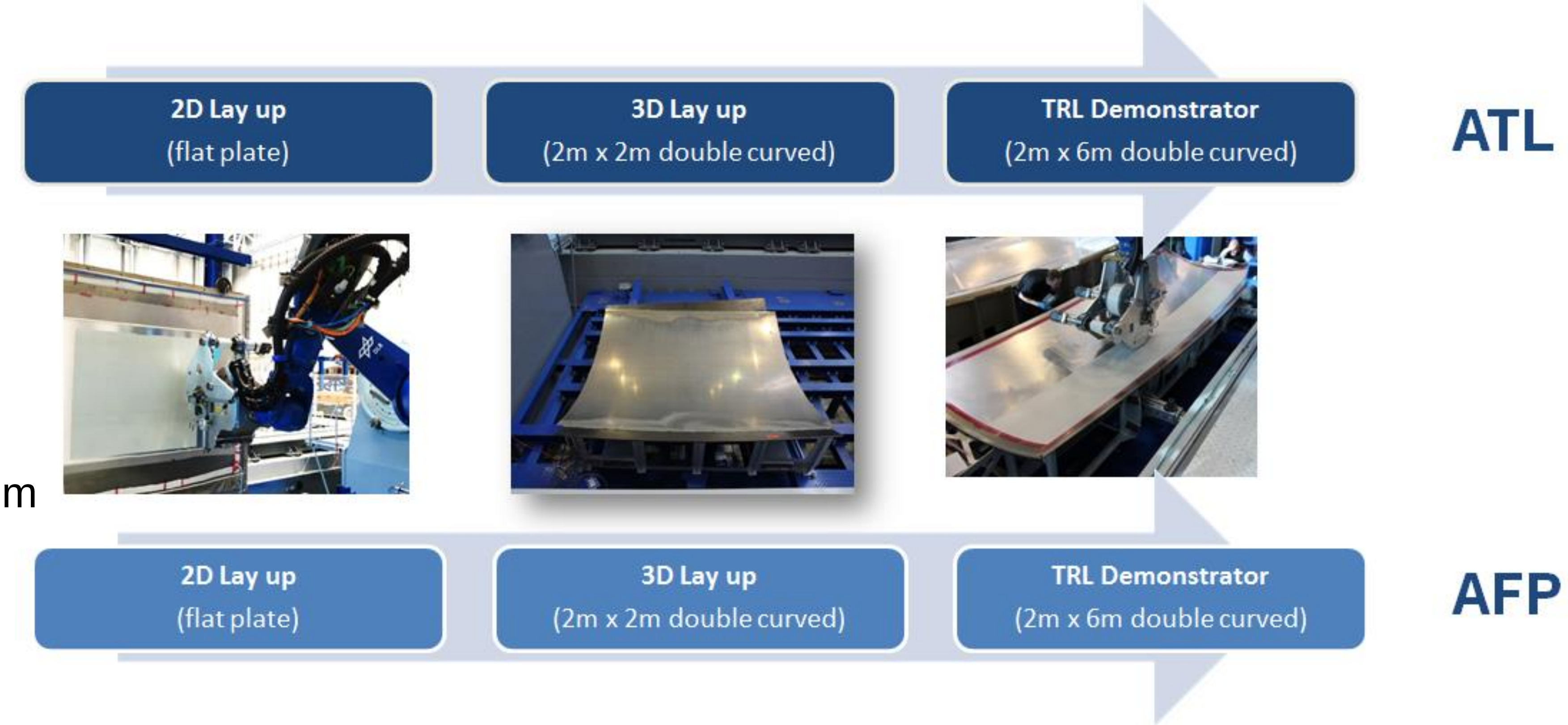


Automated, Quality Assured Production of Fiber Metal Laminates Automated Placement of Glass Prepregs - Motivation - Approach

Project goals

Increased productivity through the use of AFP technology for non-overlapping GF lay-up for double-curved components

- Process parameters
  - Temperature (<50°C)
  - Compaction (1200 N)
- Repeatability (σmax ~0,6 mm)
  - Steering
    - ATL (r ~ 28 m)
    - AFP (r ~ 6 m)
    - Needed steering r ~ 12 m
- …



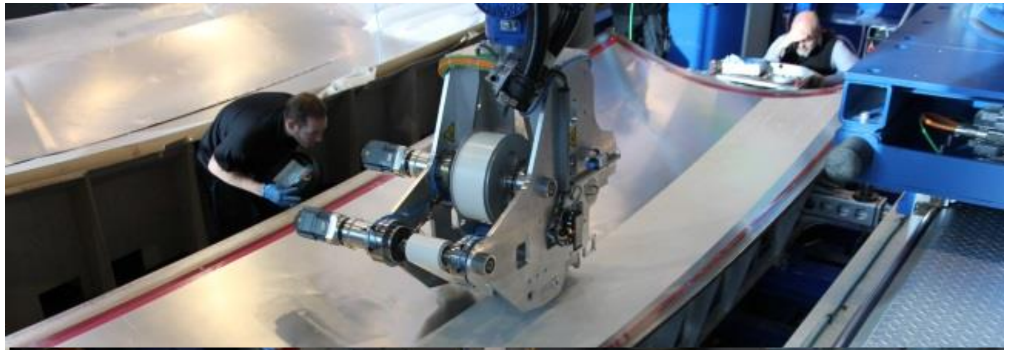
Automated, Quality Assured Production of Fiber Metal Laminates
Automated Placement of Glass Prepregs – ATL lay-up

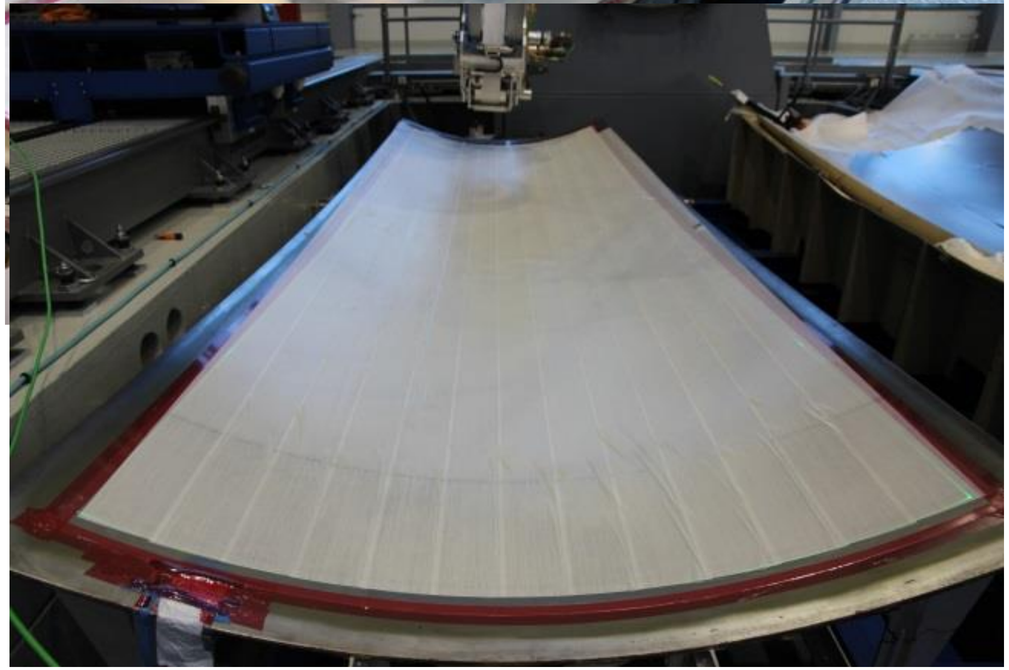
Used materials

- Tooling: CoFuI2 – double curved – 2m x 6m
- GF prepreg with a width of 150 mm
- Aluminum folils with a thickness of .3 and .4 mm
- 3/2 - FML

Results TRL4 Demonstration

- Succesful lay-up, BUT…
  - No steering possible (pre-trials)
  - Overlaps!!!
    - Measured overlaps 0° plys ~12 ± 1mm (Sim. 12,1 mm)
    - Measured overlaps 90° ply ~2 ± 1mm (Sim. 2,2 mm)





Automated, Quality Assured Production of Fiber Metal Laminates
Automated Placement of Glass Prepregs – AFP lay-up

Used materials

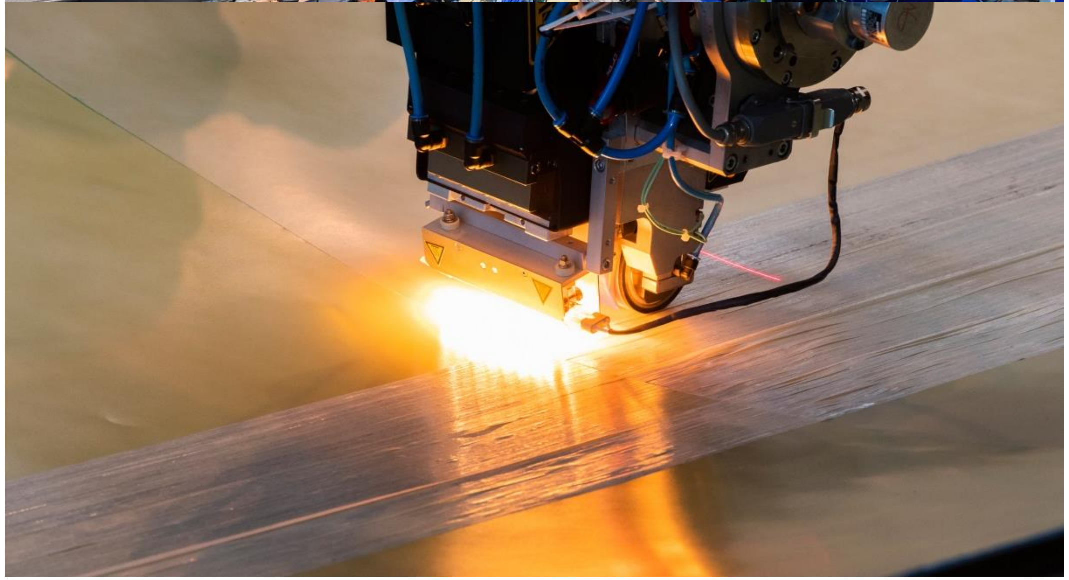
- Tooling: CoFuI2 – double curved – 2m x 6m
- GF prepreg with AFP 4 x ¼” (6,35 mm)
- Aluminium folils with a thickness of .3 and .4 mm
- 3/2 – FML

Challenge

- Steering possible, BUT…
    - No gap, no overlap
    - No fibre angle derivation

Results TRL4 Demonstration

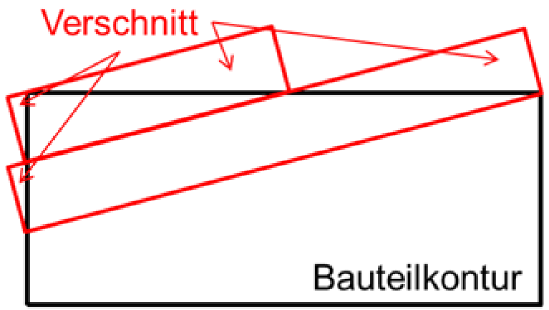
- Succesful lay-up
    - No overlaps, no gaps
    - Fibre angle derivation of ~2,4°

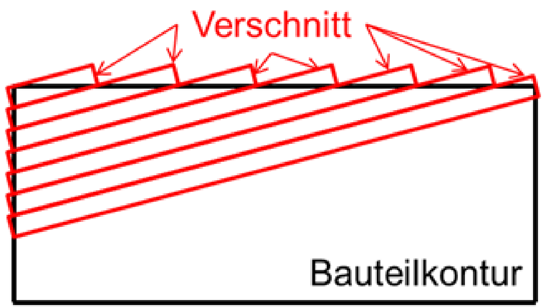


Automated, Quality Assured Production of Fiber Metal Laminates Automated Placement of Glass Prepregs – AFP lay-up

More results

- Comparison between ATL and AFP
  - Total area to lay up : 33,3 m²
    - AFP: 33,5 m² (+0,6 %)
    - ATL: 36,1 m² (+8,5 %)



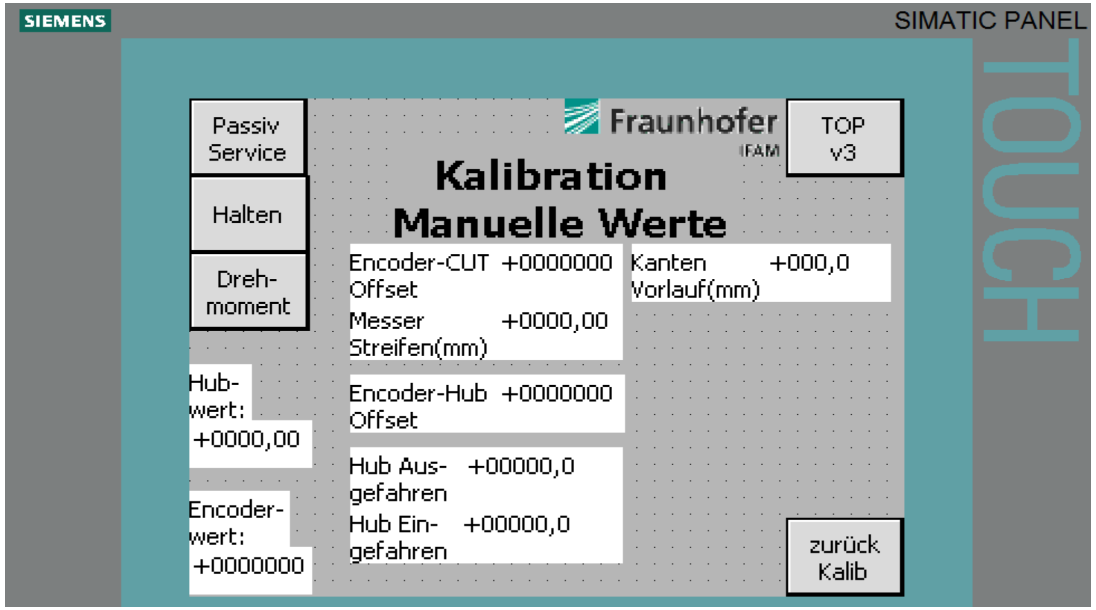


- AFP is 28 % slower than ATL (~12 m/min)

	Automated Tape Lying (ATL)	Automated Fibre Placement (AFP)
0° plies	16 min 05 sec (14 Courses)	19 min 30 sec (18 Courses)
90° plies	16 min 40 sec (33 Courses)	22 min 10 sec (49 Courses)
Total time (2x0° + 2x90°)	**65 min 30 sec**	**83 min 20 sec**

Automated, Quality Assured Production of Fiber Metal Laminates
Automated Placement of Adhesion Films

- Adhesive films with two side bonding
- Films always have backing paper from one side and sometimes a liner from the other side
- Aim: Build a end-effector which can be mounted on a industrial robot to apply different kind of adhesive films
- Labelling of adhesive film roller by RFID incl. visualisation on a user interface
- Simplified initial operation and calibration by program routines
- Accuracy: ± 1mm
- Layup speed: more than 13 m/min



Automated, Quality Assured Production of Fiber Metal Laminates
Automated Placement of Adhesion Films

Version 2

Calculation roll diameter

Measuring tensile force

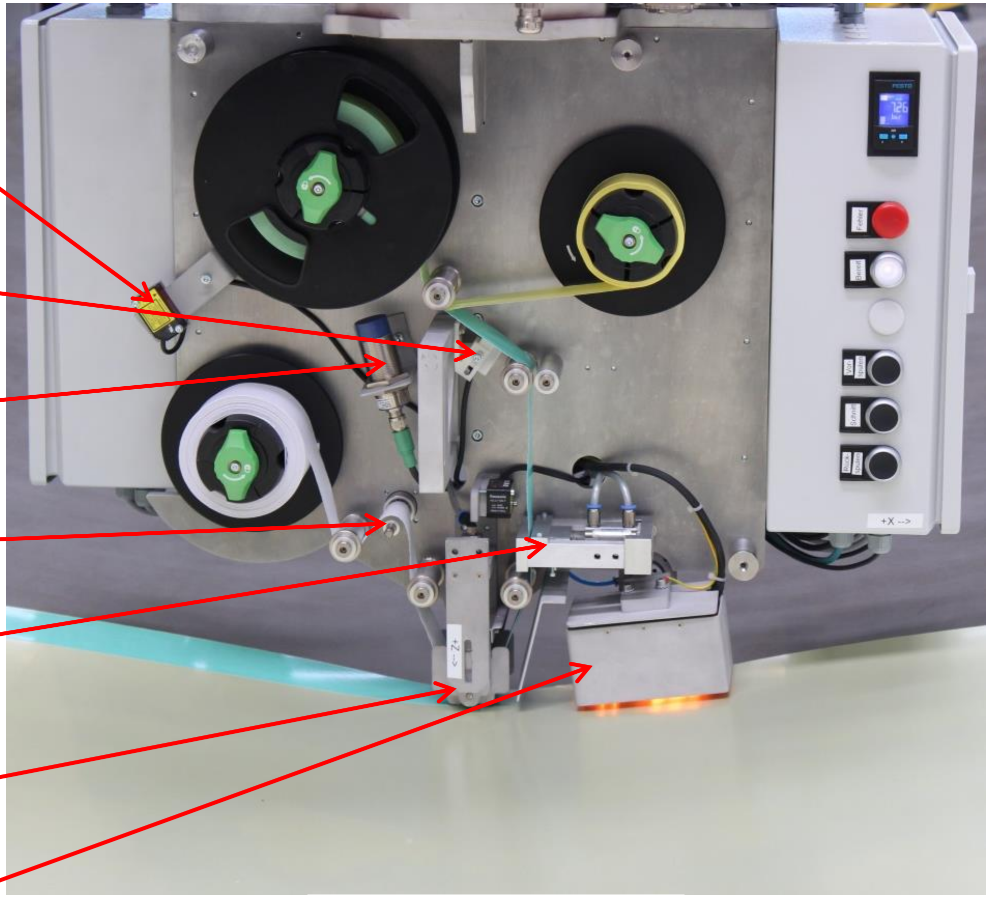
RFID sensor

Rotatory encoder

Knife

Pressure roller

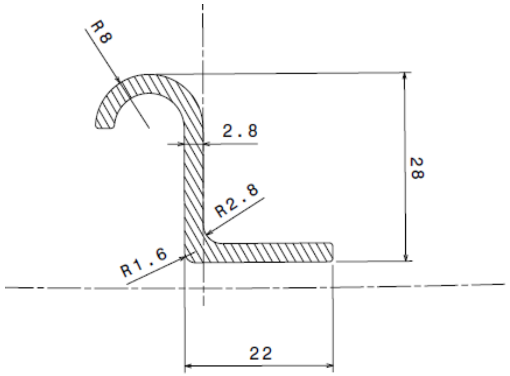
Heat source

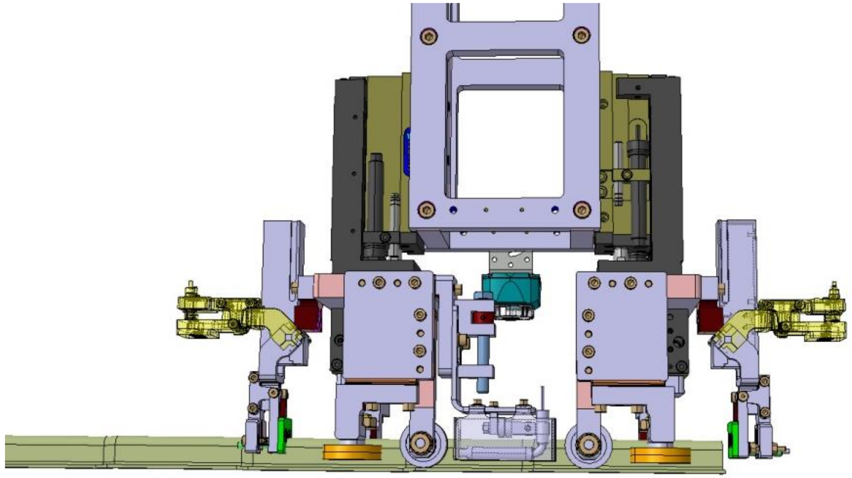


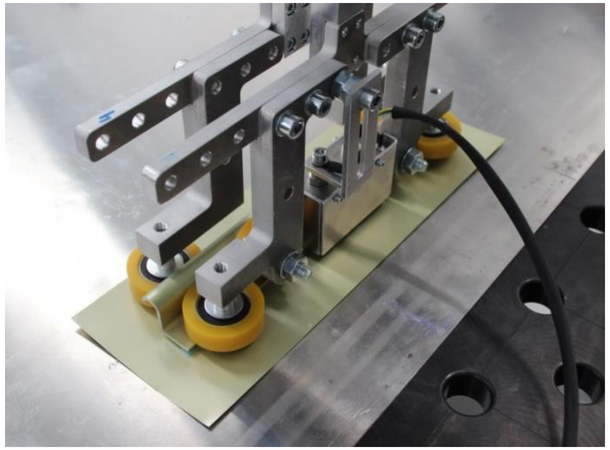
Version 3

Automated, Quality Assured Production of Fiber Metal Laminates
Automated Placement of Z-Stringers

- Handing a 6 meter long stringer with two cooperating industrial robots → end-effector for holding and integration
- Integration end-effector must heat up the adhesive film, apply a vertical force and move along the stringer
- Integration on 2D and 3D surfaces possible
- Offline programming of the paths incl. reachability, collision check and movement sequences





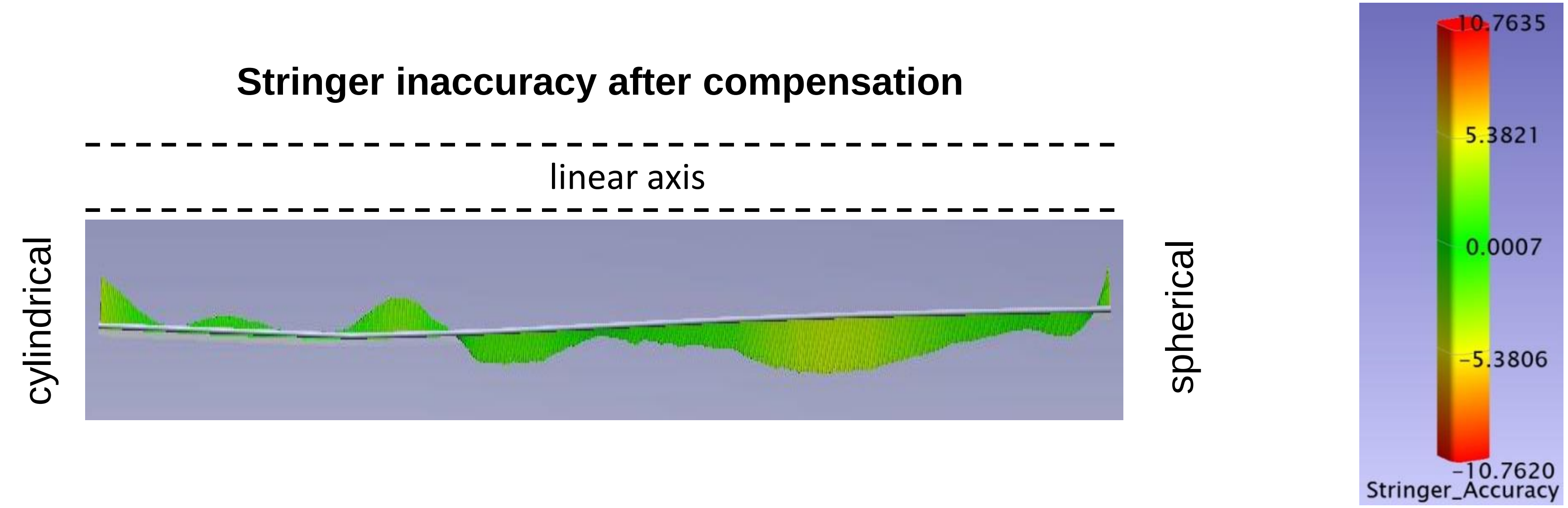


Automated, Quality Assured Production of Fiber Metal Laminates
Automated Placement of Z-Stringers

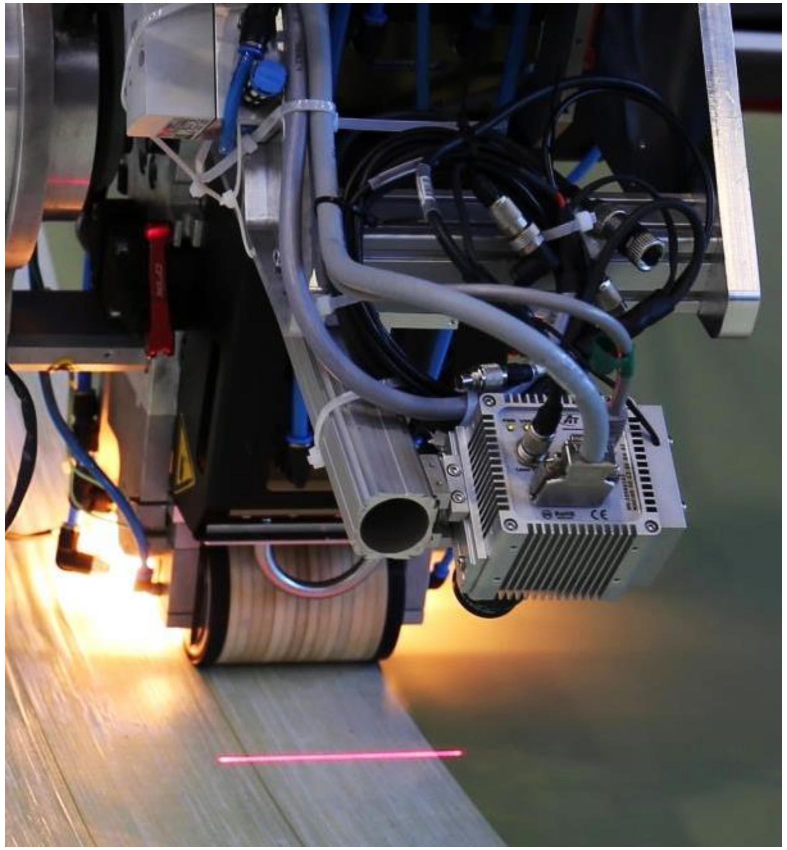
Development of a compensation strategy to increase the accuracy of the integration process

- Compensation (robot + linear axis + console):
  - Max. inaccuracy: ± 1.35 mm
- Expected process accuracy: ± 1.9 mm @ 6Sigma
  - If the needed tolerance is bigger than the accuracy at 6Sigma then zero out-of-spec parts are expected

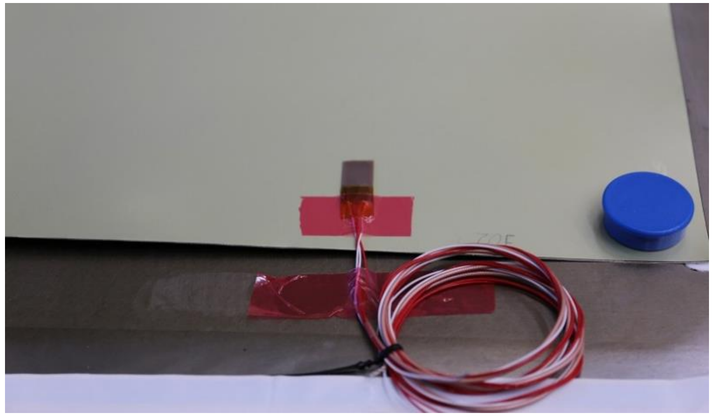
Stringer inaccuracy after compensation

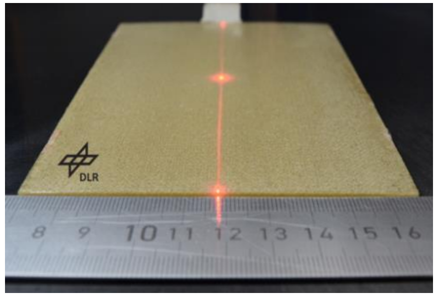


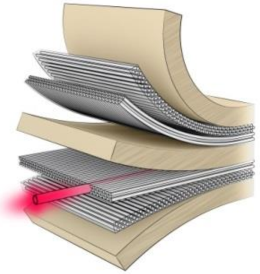
Automated, Quality Assured Production of Fiber Metal Laminates
Inline Quality Assurance Along the Process Chain

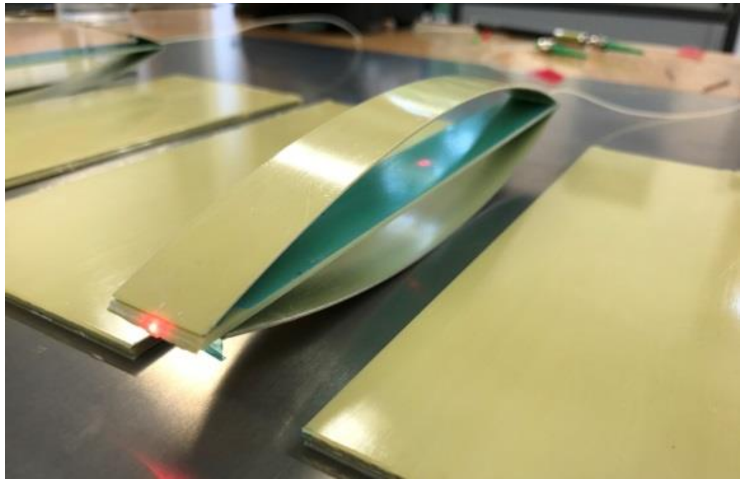


Lay-up Process









Curing Process

Automated, Quality Assured Production of Fiber Metal Laminates Conclusion

Project-Video

Automated, Quality Assured Production of Fiber Metal Laminates
Thanks to our partners

Federal Ministry
for Economic Affairs
and Energy

AIRBUS

synthesites

PREMIUM
AEROTEC

FFT


Thanks
for your attention!